pp. 44–84, Taf. iii.–v.), discusses new Dragonflies from Formosa, South China, Tonkin and the Philippine Islands. Amongst others, two species of the genus *Idionyx* are described as new. In the case of one of these, *I. claudia* Ris, from Tsa-Yin-San, the male carries on the under side of segment 7 of the abdomen a brush of hairs exactly similar to that which I have described as occurring in *I. dohrni borneensis*. Dr. Ris figures this feature in his paper (*loc. cit.* p. 83, fig. 18). The second paper (Tijdschrift voor Entomologie, Deel lv. 1912, pp. 158–182, pls. 6, 7, 8) contains an account of Odonata from Java and Krakatau. The characters of the genus *Disparoneura* and *Caconeura* are discussed, and a specimen of *D. humeralis* from Mula (Java) is recorded.

6. On the Structure of Bone in Fishes: a Contribution to Palæohistology. By Edwin S. Goodrich, M.A., F.R.S., F.Z.S., Fellow of Merton College, Oxford.

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(Text-figures 13–16.)

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In a paper on the Scales of Fishes, published in the 'Proceedings' of this Society five years ago (1), I showed that the so-called "Ganoid" scales are of two kinds, differing fundamentally in minute structure and mode of growth. Scales of the first kind, to which the name Cosmoid was given, are typically covered with an outer layer of cosmine, and grow by the addition of new cosmine at the edge and new layers of bony tissue on the inner surface. The second kind, the true Ganoid scale, grows by the addition of new complete concentric layers, formed of cellless ganoine on the outer surface and bony tissue on the inner surface. Cosmoid scales are found in the Dipnoi and Osteolepidoti (extinct Crossopterygii), and in these only. True Ganoid scales occur only in the Actinopterygii and Polypterini (which probably belong to the Actinopterygii, 2). Moreover, it was further shown that the Ganoid scales can also be distinguished into two varieties—the Palæoniscoid and the Lepidosteoid. The former is characterised by the presence of a middle cosmine-like layer, and occurs only in the Chondrostei (Palæoniscidæ and their allies) and in the Polypterini; while the latter variety—the Lepidosteoid scale—is found in the Orders Amioidei (Protospondyli, + Pholidophoridæ, and Oligopleuridæ) and Lepidosteoidei (Lepidosteidæ and Aspidorhynchidæ). The lepidosteoid scale is easily distinguished by the absence of the middle cosmine-like layer and by the presence of a system of delicate tubules running through and at right angles to the bony layers. The tubules have been described by Reissner (5), Hertwig (3), and Nickerson (4)

in the scales of *Lepidosteus*, and by myself in those of various extinct Amioids and Lepidosteoids (**1**, **2**). They branch, as a rule, only at their inner end, and pass outwards to the surface. In the living tissue they are occupied by the long protoplasmic processes of large cells on the surface of the scale. Probably, these remarkable cells are merely modified bone-cells, which, instead of becoming buried in the ostein matrix, remain outside it while retaining their connection, by means of the long process, with the place they originally held. This interpretation is illustrated in text-fig. 13.

Text-fig. 13.

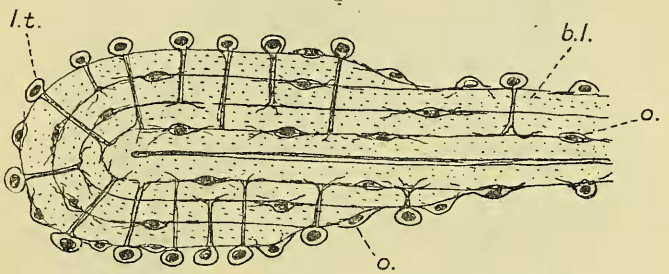


Diagram illustrating the structure and growth of lepidosteoid bone.

b.l., bony lamella; *l.t.*, lepidosteoid cell; *o.*, osteoblast or bone-cell.

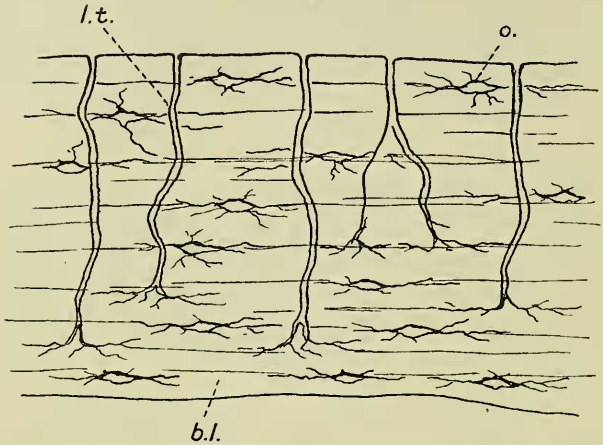
It follows that the Actinopterygii can be classified into two large groups according to the structure of their scales: the first is distinguished by the possession of palæoniscoid scales, and contains the Chondrostei (with which the Polypterini should probably be placed, **2**); the second group contains the Amioidei (Protospondyli, Pholidophoridæ, and Oligopleuridæ) and the Lepidosteoidei (Ætheospondyli).

Now it might be expected that this striking difference in the histological structure of the true ganoid scales would also be found in the cranial plates and other dermal bones of these fishes, and this is indeed the case. The dermal bones resemble the scales not only in appearance, but also in microscopic structure. Often the resemblance is so close that they cannot be distinguished; but the dermal bones may, of course, lose the covering of ganoine, as sometimes happens with the scales themselves in the more modified forms. Thus, whereas lepidosteoid tubules are never found in any part of the skeleton of the Polypterini or Chondrostei, they occur in the dermal bones of all the recent and extinct Amioidei and Lepidosteoidei I have been able to examine, with a single possible exception (*Oligopleurus*) to be discussed later*.

* I am much indebted to Dr. A. Smith Woodward for the supply of most of the material on which these researches were carried out, and to Miss R. Harrison for the preparation of a large number of microscopic slides of the bone of various fishes.

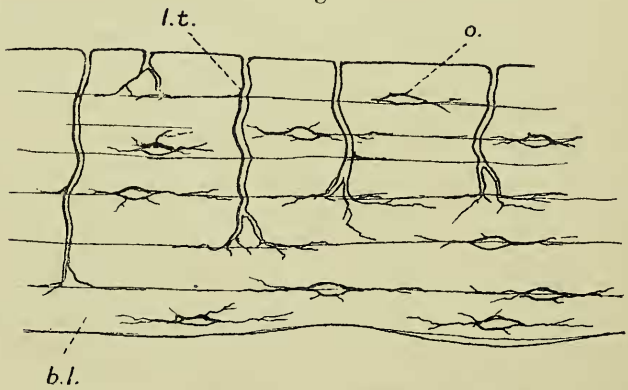
Not the dermal bones alone, however, show the lepidosteoid structure, but the *whole endoskeleton* as well. The skull-bones, the ribs, even the vertebral centra, are all provided with the characteristic tubules traversing the bony lamellæ, just as in the

Text-fig. 14.



Enlarged view of a section of the endoskeletal fin-ray of *Lepidosteus osseus*. Lettering as in text-fig. 13.

Text-fig. 15.

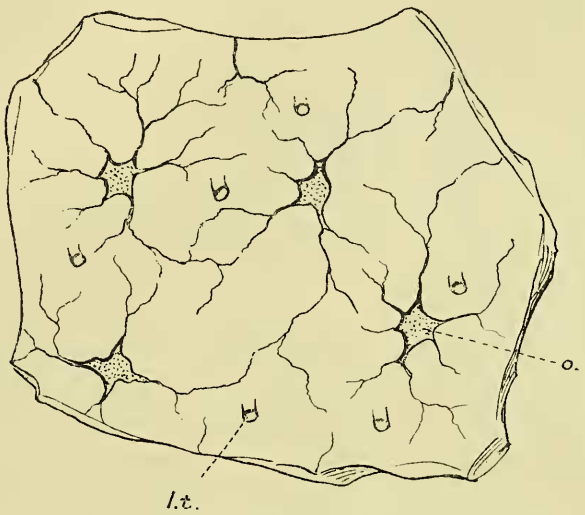


Enlarged view of a section through the neural spine of *Amia calva*. Lettering as in text-fig. 13.

scales (text-figs. 14–16). This remarkable and interesting fact has not, so far as I am aware, hitherto been observed. It follows that, from the examination of the minutest fragment of the

skeleton of a living or extinct species of fish, we can decide whether or not it belongs to the Amioidei and Lepidosteoidei, or to some other group. The histological structure of the bone may therefore be of the greatest practical value for the identification of fragmentary specimens*. It also may prove of great importance in the interpretation of phylogeny.

Text-fig. 16.



Enlarged view of a fragment of the vertebral centrum of *Ophiopsis*. Lettering as in text-fig. 13.

We cannot as yet determine for certain which type of bone is the more primitive; but I am strongly inclined to believe that the lepidosteoid type is the more specialised form, some of the osteoblasts having become modified to form tubules. This conclusion is supported by the evidence of palæontology, since no Amioid or Lepidosteoid is known below the Permian, while Chondrosteans occur in the Devonian strata. In the absence of decisive evidence we may suppose that the lepidosteoid structure first appeared in the scales, then spread to the dermal bones, and, finally, reached the deepest parts of the endoskeleton—this, of course, is mere conjecture. At all events, since we find ordinary bone in all the Osteolepidoti, Cœlacanthini, Polypterini, and

* The following is a list of the Actinopterygii examined:—Lepidosteoidei: *Lepidosteus, Aspidorhynchus.* Amioidei: Eugnathidæ—*Eugnathus, Caturus, Heterolepidotus.* Pachycormidæ—*Pachycormus.* Semionotidæ—*Lepidotus, Dapedius.* Macrosemiidæ — *Macrosemius, Ophiopsis.* Pycnodontidæ — *Mesturus, Gyrodus.* Amiidæ—*Amia.* Pholidophoridæ—*Pholidophorus.* Oligopleuridæ—*Spathiurus, Oligopleurus, Œnoscopus.* Also *Leptolepis, Thrissops,* and a large number of Teleosts.

Chondrostei, it would seem that the Amioidei and Lepidosteoidei have been derived from a common ancestral form which developed the lepidosteoid scale and bone, diverging in this and other respects from the remainder of the Teleostomi.

It becomes now a matter of great interest to ascertain from which group the Teleostei may have been derived. On general anatomical grounds they would certainly be associated with the Amioidei (2). But so far I have been unable to discover the lepidosteoid structure either in the scale or in the skeleton of any living or extinct species of Teleost, even after the examination of representatives of a very large number of families. In the lower Teleostei (including the Leptolepidæ) the bone is of the ordinary structure, similar to that of *Osteolepis* or *Palæoniscus*; but, as is well known, in the higher forms it becomes generally very much modified, chiefly owing to the loss of the bone-cells. Only in the Fistulariidæ does the structure of the bone recall that of the Amioid. Even here, however, the resemblance is not close, and I have not been able to convince myself that the fine canals described by Stewart (6) are really homologous with lepidosteoid tubules.

In connection with the phylogeny of the Teleostei it is interesting to note that *Oligopleurus vectensis* A. S. W. has no lepidosteoid tubules in its endoskeleton. *Oligopleurus esocinus* Th. I have not had an opportunity of examining; but *Spathiurus* and *Œnoscopus*, the only other genera belonging to the family, have the typical lepidosteoid structure in the scales, dermal bones and endoskeleton. Associated with a skeleton of *Oligopleurus vectensis* in the British Museum is a plate, either a scale or a dermal scale-like bone, of typical lepidosteoid structure; it cannot, however, be made out for certain whether this bone belongs to the skeleton or not. *O. vectensis* certainly differs in bone-structure from other Amioids, and probably should be placed not with the Oligopleuridæ, but with the Teleostei *.

We may suppose that the common ancestor of all the Holostei (Amioidei, Lepidosteoidei, and Teleostei) was some primitive Actinopterygian with lepidosteoid scales, but in which the lepidosteoid structure had not yet penetrated to the endoskeleton. If this supposition is correct, "*Oligopleurus*" *vectensis* might perhaps be a representative of such an unspecialised group. Placed by some authors among the Amioids, and by A. Smith Woodward among the primitive Teleosts (7), it certainly appears to be a somewhat intermediate form.

As a provisional hypothesis, the view may be adopted that the Amioids and Lepidosteoids on the one hand, and the Teleosts on the other, diverged from a primitive group possessing lepidosteoid scales and ordinary bone; and that in the former the lepidosteoid structure spread inwards over the whole endoskeleton. The extreme modification of the scales in the Teleost series would

* Mr. Regan informs me that *O. vectensis* is without fulcra, and resembles the Leptolepidæ in the structure of the tail, and should be included in that family.